Presented at the Particle Accelerator
Conf., Chicago, Ill., March 1-3, 1971

UCRL-20179
Preprint c.2

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February 1971

AEC Contract No. W-7405-eng-48

LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

UCRL-20179

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PCM TELEMETRY SYSTEM FOR 3-MV SUPERHILAC INJECTOR*

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Introduction

A time-division multiplex communications system using pulse code modulation (PCM) has been built for the new 3-MV SuperHilac injector. Transmission between the high-voltage terminal and ground uses light beams generated by light-emitting diodes and is received by photodiodes. With each accelerator pulse a sequence of 384 time slots is transmitted--each defined by a clock pulse transmitted over an adjacent light beam. Binary information is then conveyed by the presence or absence of pulses in the appropriate time slots. This system can handle, in either direction, 16 parallel analog input channels which are encoded into 16 12-bit binary coded decimal (BCD) serial words and 192 parallel "ON-OFF" input channels which are also encoded into 16 12-bit serial words. Thus a serial transmission in either direction consists of 32 12-bit words.

Optical Modulator

The optical modulator consists of a pulsed light-emitting diode (LED), Monsanto ME2A, emitting infrared light at 9000 Å. The light receiver is an E.G.&G. SGD-100 which has a response peak at 9000 Å. Pulse width is 1 μsec and the repetition rate is 50 kHz. Figure 1 shows a photo and schematic of the sender and receiver. The honeycomb grating in front of the lens shields the receiver from stray light generated by sparks.

General Description

Figure 2 shows the basic elements of one PCM data path, from terminal to ground end. One optical link is used to send clock information from the ground end to the terminal so that the data transmitters and receivers will be synchronized. The second optical link sends PCM data up to the terminal, while a third optical link sends PCM data from terminal to ground. In addition to the PCM data channels, there are also two analog optical channels which continuously monitor arc current and extractor potential in the ion source.

System Programmer Description

Referring to Fig. 2, the ground-end clock is gated on by the accelerator on pulse and is internally gated off after 32×12 clock pulses. This means that data will be sampled at the SuperHilac pulse rate, which is about 30 pulses per second.

In addition to shifting information in and out of the serial data channels, the 50-kHz clock also drives a modulus-12 counter which puts out 1 pulse for every 12 input pulses. This output pulse then drives a 1 of 32 decoder which sequentially specifies which 12-bit data word is to be processed. After processing a 32-word pulse train the system programmer produces a signal to reset the counters.

Data Input and Output

The 16 analog inputs are sampled by a 16-channel MOSFET multiplexer driven by outputs 1 through 16 of the 1 of 32 decoder. The multiplexer output feeds a successive approximation analog to digital converter (ADC) which produces a 12-bit BCD encoded serial output. Input information is stored in 16 12-bit registers, which shift their data out as they are in turn selected by outputs 17 through 32 of the 1 of 32 decoder. The data outputs of the ADC and switch registers are "OR"ed onto a single serial channel. After being received on the other end, the data are shifted into 32 12-bit holding registers. Since the ground and terminal ends are synchronized, the received, or output, data have the same word and bit location as the transmitted data. The first 16 holding registers are used to drive nixie readouts while holding registers 17 through 32 drive relay buffers. These relays not only control the on-off functions but also operate motor-driven helipots which control pulse width and amplitude levels.

Circuit Protection

Special precautions were taken in the terminal portion of the telemetry to protect the delicate integrated circuits from 3-MV spark-induced transients. These precautions include double shielding, input and output isolation with either photon decouplers for analog or fast pulsed data, or relays for switch data. All low-frequency inputs and outputs have rf filters. Lines that cannot have RC filtering because of frequency requirements have fast transient suppressors instead.

Conclusion

The availability of suitable integrated circuits has made it possible to develop a PCM telemetry system for communication between the high-voltage terminal and ground. Because PCM exchanges bandwidth and signal-to-noise ratio exponentially, rather than linearly, it is possible to more closely approach Shannon's information capacity limit than with other types of modulation. This exhibits itself in the present case by providing 16 analog channels with a resolution of one part in 4096 and 192 "ON-OFF" channels. There is enough time between accelerator pulses to expand the number of channels by a factor of 4 if it ever becomes necessary.

*Work done under the auspices of the U. S. Atomic Energy Commission.

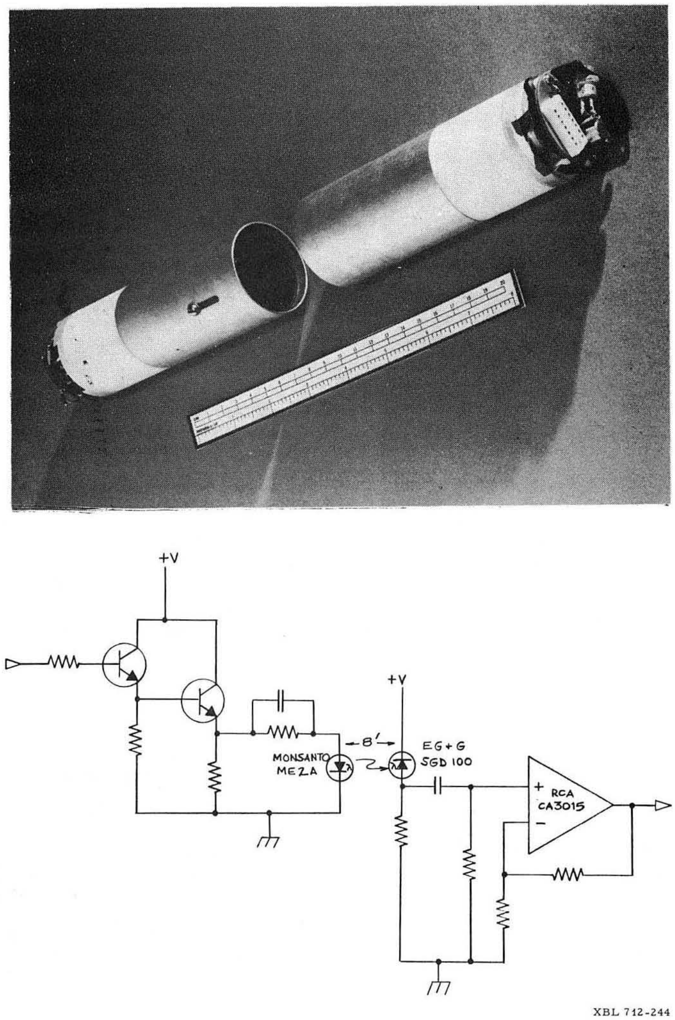

Fig. 1. Photograph and schematic of sender and receiver.

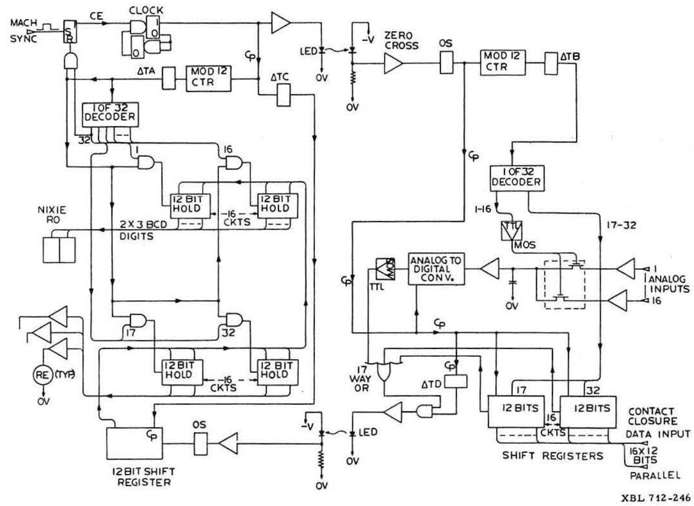

Fig. 2. Basic elements of one PCM data path, from terminal to ground end.

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